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Implementing Agreement on a Co-Operative Program on Inertial Fusion Energy

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IMPLEMENTING AGREEMENT
ON A CO-OPERATIVE PROGRAM ON INERTIAL FUSION ENERGY

Contracting parties: US, Japan, Spain, Italy, France, United Kingdom, Germany, Russian Federation

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I. Objective and Scope

The Programme to be carried out by the Contracting Parties within the framework of this Agreement shall consist of co-operative research, development, demonstrations and exchanges of information regarding inertial fusion energy (IFE). This shall include: 1) Nuclear Technology, 2) Fusion Materials, 3) Environment, Safety and Economics, 4) Laser Drivers, 5) Ion Beam Drivers and Beam/Plasma Interactions, 6) Target Production, Injection and Tracking, 7) Fusion Diagnostics, 8) Driver/Plasma Interactions, 9) Fast Ignition and 10) Power Plant Design Studies. Annexes to this agreement will describe specific tasks in each area.

II. Identification and Initiation of Tasks

III. Executive Committee

IV. Operating Agents and Subtask Leaders

V. Administration and Staff

VI. Finance

VII. Intellectual Property

VIII. Legal Responsibilities and Insurance

IX. Legislative Provisions

X. Admission and Withdrawal of Contracting Parties

XI. Final Provisions

Annexes

Annex I Nuclear Technology

Solid Breeding Blankets — The current Laser-IFE chamber work in the US focuses on a fluidized solid breeding material (Li_2O). Key issues are radiation damage, swelling, and erosion.

Liquid Breeding Blankets — Heavy ion chamber work in the US currently focuses on the use of thick-liquid breeding materials (Flibe) and first wall protection schemes. Key issues include the generation of adequate liquid jets, the disruption of the liquid by the fusion blast, and the re-establishment of a protective liquid pocket and low vapor pressure at a rapid (5-10 Hz) rate. Study of these issues will require measurement of key material properties such as vapor pressure, chemical stability, tritium absorption, etc.

Neutronics — IFE needs are comparable to those for MFE. Key issues are the use and benchmarking of three-dimensional neutronics codes and nuclear data, bulk shielding, final focusing element shielding, tritium breeding adequacy, etc.

Tritium Processing — IFE interests include the recovery of tritium from both solid and liquid breeding materials.

Significant overlap between this subtask and those in Target Production, Injection, and Tracking is expected.

Chambers and Subsystems — Design and development of first wall concepts, chamber clearing calculations and experiments, isochoric heating experiments, and hydrodynamics of thick liquid walls.

Annex II Fusion Materials

Pulsed Irradiation Effects — Both experimental and theoretical analyses of pulsed irradiation effects are needed. Molecular dynamics simulations may play an important role. Codes must be benchmarked at relevant fluences to give confidence in their predictive ability.

Self-Annealing at High Temperatures — Operation of critical components at high (80-90% of melting point) temperatures has been proposed in some IFE designs. In particular, some work suggests that final focusing components may self-anneal when operated at high temperatures.

Simultaneously Imposed Stresses — IFE first walls may be subjected to multiple stresses simultaneously. These stresses arise from irradiation, shocks, and high heat fluxes.

Damage to Final Focusing Optics and Optical Coatings — For Laser-IFE, protection and survivability of final optics, final focusing optics, and optical coatings are key issues. Heavy ion designs must protect the final focusing magnets and sustain cryogenic temperatures in close proximity to the fusion chamber.

Flowing Solid Breeder Materials — Several IFE power plant designs call for the use of flowing solid breeder materials such as Li_2O granules that are fluidized in a helium carrier gas. The ability to reliably flow such granules and the effects of radiation damage and swelling need to be explored.

Neutron Sources for IFE — This area will require close coordination with our colleagues in the MFE community. We need to ascertain what portion of the IFE issues can be adequately addressed with proposed facilities. It may be possible to introduce minor design changes into these facilities in order to increase their usefulness to the IFE community. We also need to understand what additional facilities will be required to address the outstanding issues. A short-pulse laser-driven neutron source may be needed.

Coordination of Silicon Carbide and Carbon Composite Work — Work is underway in the MFE community to study the performance of silicon carbide and carbon composite materials. This work, however, needs to be extended to reflect typical IFE temperature ranges and the pulsed nature of the IFE fusion source.

Annex III Environment, Safety, and Economics

Tritium Safety — Examination of in-vessel tritium source term and tritium behavior in IFE components is needed. Work needs to be tailored towards IFE materials and conditions (e.g., carbon composites and high surface heat fluxes).

Transient Thermofluid Experiments and Modeling — Code benchmarking (including against experiment) of relevant fusion safety codes is needed. Example codes include MELCOR, ATHENA, TRAC, and INTRA. Similar work is being performed in the MFE community, but materials, conditions, and types of accidents are different in some cases.

Activation Products — Differs from work in MFE community due to materials (e.g., high-Z), mechanisms (e.g., generation of dust source term), and the pulsed nature of the neutron source.

Radioactive Waste Management — The IFE community is very interested in the recent work on recycling and clearance limits. An IFE-specific concern is the "on-line" recycling of high-Z target materials within an indirect-drive power plant.

Failure Rate Database — Generic fusion system failure data (e.g., tritium storage and handling systems) is needed. IFE component reliability information should be exchanged. This includes current experimental systems as well as systems that would ultimately be present in an IFE power plant (e.g., optical components for current and next-generation facilities).

Socioeconomics — The IFE community is interested in joint cost analysis using fusion systems codes. Such analyses will enable cost estimates to be performed on a comparable basis.

Annex IV Laser Drivers

Diode Pumped Solid State Drivers — The IFE community is interested in design of DPSSL driven power plants. This task focuses on development of low cost diode arrays, development of final optics configurations and research on survivability, research on crystalline laser host materials, research on gas cooled amplifiers.

KrF Laser Drivers — Design of KrF driven power plants is also of interest. This task focuses on development of recirculating gas amplifiers, assessments of hibachi reliability, final optics development.

Annex V Ion Beam Drivers

Accelerator Components — Design and development of key accelerator components such as ion sources, pulsers, accelerating modules, transport systems, etc. Low-cost metglas and solid state power switching are needed.

Accelerator Systems — Accelerator design requires balance and trade-offs in the systems configuration. Work on integrated systems modeling for ion drivers is needed to identify attractive design configurations and guide R&D.

Beam Transport — Beam transport from the final focus magnets through the chamber to the target is a key issue for ion driver. Theory and experiments on beam transport are needed.

Final Focusing — Targets require focusing of the ion beams to small, precisely located spots. Experimental and theoretical investigations of various beam focusing techniques are needed. Design considerations for protecting final focus magnets must be included.

Annex VI Target Production, Injection and Tracking

Target Production — Key target production issues include the use of cryogenics, target fill and layering technologies, tritium inventory within the fabrication facility, fabrication techniques and reliability, and the use of high-Z materials for indirect-drive targets.

Target Injection and Tracking — Injection and tracking issues concentrate on survivability of targets under high accelerations and within the chamber environment, ability to track targets within the chamber, repeatability of target injection, and the ability to correct and/or tolerate small errors in positioning (e.g., beam steering).

Annex VII Fusion Diagnostics — Development of x-ray, neutron and other diagnostics for nearly ignited and ignited targets.

Annex VIII Driver/Plasma Interactions — Design of laser and heavy ion beam driven targets, beam/plasma interaction studies.

Annex IX Fast Ignition — Joint experimental and analytical studies of interaction of short pulse lasers with hot dense plasmas, integrated experiments on efficiency of penetration of compressed targets with ultra short laser pulses.

Annex X Power Plant Design Studies — Design of heavy ion, laser, Z-pinch, and Fast Ignition IFE power plants, integrating the results of the other annexes.